MORPHOLOGY OF THE HEAD CAPSULE OF *Evania appendigaster* (LINN.) [EVANIDAE : HYMENOPTERA]

DISSERTATION
SUBMITTED IN PARTIAL FULFILMENT FOR THE DEGREE OF
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(Entomology)

BY
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DEDICATED TO
MY
BELOVED MOTHER
WHO LEFT FOR HEAVENLY ABROAD
ON
SEPTEMBER 3, 1978

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This is to certify that Mr. Mohd. Khalid has completed his dissertation on the skeleto-muscular mechanism of the cranium of Evania appendigaster (Linn.) under my supervision for the degree of Master of Philosophy. This amounts to an original contribution and a distinct addition to the existing knowledge on the subject. I am satisfied with his work and permit him to submit this dissertation in partial fulfilment of the award of the degree of Master of Philosophy of Aligarh Muslim University, Aligarh.

Shujauddin
1/7/82

(Shujauddin)
Lecturer in Zoology.

SKELETO-MUSCULAR MECHANISM OF EVANIA APPENDIGASTER (LINN.)

(EVANIDAE : EVANOIDEA : HYMENOPTERA)

BY

MOHD. KHALID

CONTENTS

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INTRODUCTION

Evania appendigaster (L.) is an important parasite of the oothecae of *Periplaneta americana* L. in India. It is a European species but now widely distributed in oriental regions. Keeping in view the economic importance of this parasite as an important agent of natural control of cockroaches in kitchens and stores and its easy availability in Aligarh and its surrounding areas, the present writer has undertaken the study on its morphology for his Ph.D. degree. Further, so far no work has been done on the morphology of any representative of the superfamily Evanoidea. The present study will be an addition to the existing knowledge on Evanid morphology which can be of immense help for the comparative study on morphology of parasitic Hymenoptera.

The present work deals with the study of the skeleto-muscular mechanism of *E. appendigaster* of both the sexes. Greater stress has been laid on the myology as it is difficult to fully understand the skeletal structures without their corelation with the musculature. The present study has been restricted on the cranium for the award of the degree of Master of Philosophy. The auther has also tried to make necessary morphological comparisions with other hymenopterous insects. Side by side, an attempt has also been made to compare its homologies and analogies with other important representatives of Diptera, Hemiptera, Orthoptera and Lepidoptera.

This study is greatly based on the important works of Duncan (1939) on _Vespula pensylvanica_; Snodgrass (1942,56) on honey bee; Bucher (1948) on _Monodontomerus dentipes_; Qadri (1950) on _Pyrilla perpusilla_; Alam (1951) on _Stenobracon deesae_; Rakspal (1956) on _Gryllus africana_; Akbar (1957) on _Leptocorisa varicornis_; Dhillon (1966) on _Athalia proxima_; Mathur (1970) on _Parageniaspis indicus_; Zaka (1971) on _Dacus cucurbitae_; Mathur (1977) on _Utetheisa pulchella_ and Zaka (1978) on _Bathyaulax alami_.

MATERIAL AND TECHNIQUE

The adults of Evania appendigaster (L.) of both the sexes were collected from various localities of Aligarh District, with the help of insect nets and plastic tubes. They are abundantly found in the months of March, April, September and October in kitchens, stores and main holes of sewage lines, the habitat of cockroaches, its host.

The colony of E.appendigaster was also maintained in the laboratory by exposing the oothecae of P.americana in a cage 1x1 in size. The insects thus reared were used for morphological studies.

In the laboratory, these insects were fixed in picro-chlor acitic acid fixative and Bouin's alcoholic fixative for 12 hours and were washed with 70 % alcohol for a few times to remove the excess of fixative and were finally preserved in 70 % alcohol. The first fixative proved to be suitable because it gave satisfactory results with anatomical and histological studies. The sclerotic structures were studied by treating the material with 10 % KOH solution. First of all the head of the insect was detached from the thorax and then it was boiled in 10 % KOH solution for 5-10 minutes to dissolve the muscles. After that it was washed several times with distilled water. To obtain the transparency in the skeletal structures the decolorization of the material was done by exposing the material to the fumes of nascent chlorine gas, liberated by the action of Potassium Chlorate ($KClO_3$) and conc. HCl. The decolorised cranium was then thoroughly washed with distilled water. After that it was dehydrated in ascending grades of alcohol upto 70 %. From 70 % the material was stained in carbol-aniline and 5 % acid fuchsin (alcoholic) stain . The latter stain gave comparatively better results. In the stain the material was kept for 30-60 minutes. After that it was retransferred to 70 % alcohol. The details of the structures were studied in glycerine under binocular microscope.

The myology was studied by dissecting the cranium under binocular microscope, of the specimens fixed in Picro-chlor acitic acid fixative and stained with Borax Carmine and Mallory's fluid. The second stain proved to be comparatively more excellent as it provided a contrast in colour to the muscles, nerve tissues and skeletal structures which proved helpful in tracing the origin, insertion and action of various muscles. To prepare the permanent slides of various muscles 5 % acid fuchsin (alcoholic) stain was used. This stain proved quite satisfactory for their study.

The slides were studied under binocular micrscope and the diagrams were drawn with the help of Camera Lucida (Erma Japan).

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(Mohd. Khalid)

EXTERNAL FEATURES OF THE HEAD CAPSULE

(Figs. 1, 2, 3)

The head capsule of E.appendigaster is black in colour. It is of hypognathus type. In facial view it appears triangular in outline. The dorsal area of the head capsule forms the base and the anterior end of the labrum forms the apex of the triangle. On each side of the triangular head capsule there are two big 'compound eyes' (E) which occupy dorsally the antero-lateral area of the cranium. The base of the triangle is termed as 'vertex' (Vx). In the middle of the vertex there are three ocelli which are located more or less in the middle of the vertex. Out of these three, two are lateral to the middle line and are known as 'lateral ocelli' (LO), while the third one is anterior to these two and is known as the 'median ocellus' (MO). The two lateral ocelli and the median ocellus collectively form the obtuse 'ocellar triangle' on the vertex. On the anterior surface, on each side of the middle line of the cranium, there are two 'antennae' (Ant) which are articulated with a socket known as 'antennal socket' (ASoc). The unpaired 'foramen magnum' (For) is located almost in the centre of the posterior surface of the head capsule. It is more or less oval in shape. The foramen magnum also bears a thickened rim (RiFor). The area of the posterior surface of the head capsule which surrounds the foramen magnum is depressed. On the ventral margin of the posterior surface, ventral to the foramen magnum there is an 'oral fossa'(OF) along which the gnathal appendages are suspended facing downwards. The 'anterior tentorial pits'(at) are more distinct in comparision to 'posterior tentorial pits'(pt). The whole head capsule is covered over by small hairs.

SUTURES OF THE CRANIUM

(Figs.1,2,3,5)

Most of the sutures which are present in a generalised insect are found in _E.appendigaster_. The 'epicranial'(cs), 'antennal'(as), 'pleurostomal'(ps), and 'clypeogenal'(clpges) sutures are evident on the anterior surface; 'ocular suture'(os) on the antero-lateral surface and 'occipital'(ocs), 'post occipital' (pos) and 'hypostomal'(hs) sutures on the posterior surface of the cranium. These sutures form the lines of demarcations of various sclerites of the cranium.

1. _Epicranial suture_ (Fig. 1 ; cs) :-

Apparently the 'epicranial suture' is absent. It is obliterated to such an extent that it is nothing but a only small faint line starting from the median ocellus (MO) running down the middle of the face upto a point somewhat near the antennae (Ant). It has no corresponding ridge. This faint line is termed as 'coronal suture'(cs).

The coronal suture has no bifurcations viz., the 'frontal suture.' Such an epicranial suture has been shown by Duncan (1939) in _Vespula pensylvanica_ and Alam (1951) in _Stenobracon deesae_. However, in _Pyrilla perpusilla_ Walker (Qadri,1950) and in _Dacus cucurbitae_ Coq. (Zaka,1971) only the frontal sutures are present in the form of an inverted 'V.' Zaka (1971) like Crampton (1942) in Diptera, call this suture as the 'ptilinal fissure', while Peterson (1916) in Diptera, Jobling (1932) in *Glossina palpalis*, Ferris (1950) in *Drosophila melanogaster* and Nayer (1961) in *Dacus diversus* call it as the 'ptilinal suture'. In *Leptocorisa varicornis* (Akbar,1957) the epicranial suture is well developed in the form of an inverted 'Y' while in *Athalia proxima* (Dhillon,1966) and in *Parageniaspis indicus* Alam (Mathur,1970) it is totally absent.

2. Antennal suture (Fig.1;as) :-

Each antenna is set in a sclerotic area of the cranial wall which is known as the 'antennal socket'(ASoc). The rim of the antennal socket is raised. This socket is surrounded by a suture which is known as the 'antennal suture'(as). A distnct antennal ridge is present.

A well defined antennal suture is present in *V.pensylvanica* (Duncan,1939), *L.varicornis* (Akbar,1957) and *A.proxima* (Dhillon,1966). In *P.indicus* (Mathur,1970) it is incomplete ; while in *P.perpusilla* (Qadri,1950), *S.deesae* (Alam,1951), *D.cucurbitae* (Zaka,1971) and *Utetheisa pulchella* (Mathur,1977) it is wanting.

3. Clypeogenal suture (Fig.1;clpges):-

The 'clypeogenal suture' is well developed and laterally demarcates the clypeus (Clp) from the gena (Ge). In fact it is the lateral portion of the epistomal suture. The median portion of the epistomal suture i.e. the frontoclypeal suture which demarcates the clypeus from the frons is totally wanting in E.appendigaster and therefore, the two sclerites (Frons and clypeus) can not be separated from each other on sutural basis. The clypeogenal suture of either sides connects the anterior tentorial pit (at) with the anterior articulation of the mandible (c) and continues with the anterior end of the pleurostomal suture (ps) of its side. An internal ridge is present. Dhillon (1966) in A.proxima considered epistomal suture as a compound suture consisting of a single median frontoclypeal suture and two lateral clypeogenal sutures, while Duporte (1950,57) in Lepidoptera and Mathur (1977) in U.pulchella considered laterofacial suture as a compound suture consisting of frontogenal suture and clypeogenal suture. Thus according to Dhillon, the clypeogenal suture is a part of epistomal suture while according to Duporte and Mathur it is a part of laterofacial suture.

The epistomal suture is the most controvertial suture among entomologists. However, Snodgrass (1935) says, " the anterior ends of the subgenal sutures are connected across the lower part of the face by an epistomal suture". Duporte and Bigelow (1953) in Hymenoptera say, "---the clypeogenal suture lie between the genal and lateral edges of the clypeus and extend from the anterior tentorial pits to the anterior mandibular articulations----". In V.pensylvanica (Duncan,1939) the clypeus dorsally as well as laterally is bounded by epistomal suture. In D.cucurbitae (Zaka,1971) it is absent.

4. Ocular suture (Figs.1,3 ; os) :-

Each eye (E) is externally surrounded by a distinct circular groove. This groove is known as the 'ocular suture'(os). A well defined and distinct ocular ridge is present.

A prominent ocular suture has been observed by Duncan (1939) in V.pensylvanica, Alam (1951) in S.deesae, Rakshpal (1956) in G.africana , Akbar (1957) in L.varicornis , Dhillon (1966) in A.proxima and Zaka (1971) in D.cucurbitae ; while it is absent in P.perpusilla (Qadri,1950), P.indicus (Mathur,1970) and U.pulchella (Mathur,1977).

5. Subgenal suture (Figs.1,2,3,5 ; sgs) :-

The subgenal suture runs almost vertically to the margin of the head capsule from the posterior tentorial pits (pt) to the anterior articulation of the mandible (c) of each side. It runs downwards and inwards from the posterior tentorial pits till it descends below the margin of the foramen magnum(For). Then it turns outwards and as a result a small lobe is formed which has been termed as 'post genal lobe'(Fig.2,PgL) by Alam (1951) in

S.deesae, as it possesses the extention of the post genal area (Pge). From the margin of the foramen magnum the subgenal suture of each side takes divergent course towards the facial margin and runs close to and along the line of articulation of the corresponding mandible (Md). A more or less similar suture has been shown by Duncan (1939) in V.pensylvanica and Bucher (1948) in M.dentipes. In H.graminicola (James,1926) it is totally absent.

The subgenal suture has been differentiated into two :

(i) Hypostomal suture

(ii) Pleurostomal suture

The suture which starts from the posterior tentorial pit & extends upto the posterior mandibular articulation is called as 'hypostomal suture'(Figs.2,5 ; hs). A well defined hypostomal suture has been mentioned by Mathur (1970) in P.indicus. Alam (1951) reported this suture in S.deesae in the form of a faint line without any internal ridge. In A.proxima (Dhillon,1966) and D.cucurbitae (Zaka,1971) this suture is incompletely developed. Ferris (1950) in D.melanogaster ; Bonhag (1951) in horse fly ; Albrecht (1953) in L.migratoria ; Snodgrass (1956) in honey bee and Nayer (1961) in D.diversus do not record this suture.

The subgenal suture along the ventral margin of the head capsule from the posterior articulation of the mandible (a) to the anterior articulation of the mandible (c) is known as the 'pleurostomal suture'(Figs,1,2,3 ; ps). The posterior end of this part of subgenal suture meets the corresponding hypostomal suture (hs) while its anterior end turns upwards to meets the anterior articulation of the mandible and meets the clypeogenal suture (clpges) of its side as shown by Alam (1951) in S.deesae. In A.proxima (Dhillon,1966) this suture is completely fused with the ventral margin of the cranium . In D.cucurbitae (Zaka,1971) it is wanting.

6. Occipital suture (Figs.2,3,5;ocs) :-

The occipital suture (ocs) is well developed. It is horse shoe shaped and its two arms take a down course upto last , bending outwardly to meet the subgenal suture (ps) in front of posterior articulation of the mandible (a). In other words the posterior articulation of the mandible is strengthened by pleurostomal (ps), hypostomal (hs) and occipital (ocs) sutures. This suture separates the parietal (prtl) from the posterior region of the head capsule.

A more or less horse shoe shaped occipital suture has been observed by Duncan (1939) in V.pensylvanica, Alam (1951) in S.deesae and Rakshpal (1956) in G.africana, though Duncan and Alam found this suture obliterated and faded near the vertex. In P.perpusilla (Qadri,1950) it is in the form of a ridge which extends downwards to meet the base of maxillary plate, while in

L.varicornis (Akbar,1957) it is incomplete demarcating the proximal portion of the facial surface from the distal portion. Snodgrass (1942) in honey bee; Dhillon (1966) in A.proxima, Mathur (1970) in P.indicus and Zaka (1971) in D.cucurbitae failed to trace any such suture.

7. Post occipital suture (Figs.2,5;pos) :-

The post occipital suture (pos) runs along dorsal and lateral margins of the rim of the foramen magnum (RiFor) and encircles it. At its lower extremity on either side it touches the posterior tentorial pits of the corresponding side. Post occipital ridge is present. On the ventro-lateral side of the foramen magnum the post occipital suture unites with the hypostomal suture.

This suture is clearly evident in V.pensylvanica (Duncan,1939), P.perpusilla (Qadri,1950), S.deesae (Alam,1951),honey bee (Snodgrass, 1956), L.varicornis (Akbar,1957), D.diversus (Nayer,1961), A.proxima (Dhillon,1966) and D.cucurbitae (Zaka,1971). In horse fly (Bonhag,1951) it is poorly developed while in U.pulchella (Mathur,1977) it is incomplaete. In D.melanogaster (Ferris,1950) it is totally absent.

AREAS OF THE HEAD CAPSULE

(Figs.1,2,3,5)

In E.appendigaster, the cranial areas are well defined due to the presence of most of the sutures which are distinct and clearly visible. The following areas are clearly demarcated.

1. Frontoclypeus (Fig.1; FrClp):-

As the frontal sutures are absent and the coronal suture is obliterated and is in the form of only a faint line, the area starting from the lower limits of the coronal suture (cs) ; bounded in between the two antennal sockets (ASoc); dorsolaterally and laterally confluent with the parietals (prtl); vetrolaterally demarcated from the gena (Ge) by well developed clypeogenal suture (clpges) and ventrally reaching upto the labral hinge (Lmh) is called as 'frontoclypeus'(FrClp). Due to the absence of frontoclypeal suture, the frons (Fr) can not be differenciated ventrally from the clypeus (Clp) as has been shown by Mathur (1970) in P.indicus and Mathur (1977) in U.pulchella. But due to the presence of clypeogenal suture, the clypeus can be demarcated from the gena laterally. Since each clypeogenal suture extends dorsally upto the anterior tentorial pit (at) it can be safely said that the linear course of the two anterior tentorial pits across the face may be taken as the line separating the clypeus from the frons. This is supported by the facts that the frontal ganglion (FrGng) lies approximately in the level of the anterior tentorial pits. Thus, an immaginary line running across the frontal ganglion and connecting the anterior tentorial pits would separate the frons from the clypeus. Likewise the dilators of the pharynx take their origin above the frontal ganglion and that of the cibarium below the frontal ganglion. Thus it can safely be concluded that the area above the frontal ganglion is frons (Fr) and that below the ganglion is clypeus (Clp).

However, Duncan (1939) in V.pensylvanica ; Bucher (1948) in M.dentipes ; Alam (1951) in S.deesae ; Albrecht (1953) in L.migratoria ; Rakshpal (1956) in G.africana ; Thakare (1962) in G.bimaculatus ; Dhillon (1966) in A.proxima ; Zaka (1971) in D.cucurbitae and (1978) in B.alami observed that the frons is ventrally distinguished from the clypeus by an epistomal suture. Dorsally the frontoclypeus is confluent with the vertex (Vx) above the antennal sockets as has been observed by Alam (1951) in S.deesae ; Dhillon (1966) in A.proxima and Mathur (1970) in P.indicus. However the frons is separated from the vertex by a poorly developed frontal suture in L.migratoria (Albrecht,1953) and by a well developed frontal suture in G.africana (Rakshpal,1956) and L.varicornis (Akbar,1957) and by anterior margins of ptilinal fissure in D.cucurbitae (Zaka,1971). In V.pensylvanica (Duncan,1939) the frons extends upto the median ocellus. Dorsolaterally the frontoclypeus is confluent with the parietals (Prtl). A similar observation has been noted by Duncan (1939) in V.pensylvanica ;

Alam (1951) in S.deesae and Mathur (1970) in P.indicus. However, the frons is laterally bounded by frontal suture in G.africana (Rakshpal,1956) and L.varicornis (Akbar,1957) ; by incomplete frontogenal suture in A.proxima (Dhillon,1966) and D.cucurbitae (Zaka,1971) and by laterofacial suture in U.pulchella (Mathur,1977). Ventrolaterally the frontoclypeus is separated from the gena (Ge) by the clypeogenal suture (Dhillon,1966).

Snodgrass (1935) differenciated frons from the clypeus on the sutural basis as well as on the basis of the attachment of cibarial muscles originating from the clypeus and pharyngeal muscles originating from the frons. He (1947) says, " the frons is the facial area, simply above the clypeus". He further modified his previous statements ruling out the sutural criterian and said that the two areas (frons and clypeus) are distinguished from each other in respect to the attachment of muscles on them. Later (1956) in honey bee he changed his first statement saying that the frons is the upper part of the face, laterally limited by the compound eyes and ventrally by the epistomal suture. Bigelow (1954) in Hymenoptera believes that the anterior tentorial pits of either side serve as the place of demarcation between the frons and the clypeus. But Duporte (1957) contradicts the statements of Snodgrass as well as Bigelow saying that the muscles evolutionarily may change their origins and the tentorial pits may migrate dorsally or ventrally. Later he (1960) stated, " the frons is separated from the clypeus by the frontoclypeal suture and from the gena by the frontogenal suture"

2. Parietals (Figs.1,2,3;Prtl):-

The dorso-lateral areas of the cranium constitute the parietals(Prtl). In E.appendigaster, the two parietals are separated from each other dorsally by an obliterated coronal suture (cs) while on the posterior surface they are separated from occiput (Oc) by the occipital suture (ocs). The two parietals of both the sides constitute the vertex (Vx) near top of the head. They also bear antennae (Ant) and compound eyes (E). Due to the absence of any sutural demarcation between parietal (Prtl) and frons (Fr) it is difficult to separate former from the latter. However, according to Duporte (1956,57) in Lepidoptera,followed by Mathur (1977) in U.pulchella, the laterofacial suture starts from beneath the antennal bases and continues below upto the anterior mandibular articulation, the part of it from anterior mandibular articulation to the anterior tentorial pit constitutes the clypeogenal suture and rest of it starting from the anterior tentorial pit to the bases of the antenna constitutes the frontogenal suture. As in E.appendigaster the frontogenal suture is absent,on the ground described above, a hypothetical line may be taken as frontogenal suture from the bases of the antennae to the anterior tentorial pit, demarcating the parietals from the frons.The lateral parts of the parietals are known as 'gena' (Ge). The area around the compound eyes encircled by the ocular suture (os) is known as the 'ocular sclerite'(Osc). The area of the antennal sockets within the antennal suture (as) is known as the 'antennal sclerite'(Asc).

(i) Vertex (Figs.1,2,3,5;Vx):-

The top of the head is termed as vertex(Vx). It is not bounded by any suture anterolaterally. Actually, the area between the occiput (Oc) posteriorly, frons (Fr) anteriorly and upper portions of the eyes (E) laterally is termed as vertex. Posteriorly it is separated from the occiput by the occipital suture (Figs.2,3,5 ;ocs) and laterally from the upper portions of the eyes by ocular suture (Figs.1,3 ;os). Anteriorly it is confluent with the frons due to the absence of frontal sutures. However, the area in front of coronal suture may be safely taken as frons (Fr) as suggested by Alam (1951) in S.deesae. The small triangular area which bears the three close set ocelli is known as the 'ocellar triangle' which is obtuse. A similar condition has also been recorded by Duncan (1939), Alam (1951), Snodgrass (1942,56) and Zaka (1971). James (1926) and Bucher (1948) showed that only the lateral ocelli are placed on the vertex while the median ocellus is located on the frons.

(ii) Gena (Figs.1,2,3 ;Ge) :-

The lateral area of the head capsule is known as 'gena'(Ge). It has been called 'cheek' by Snodgrass (1956) in honey bee. Each genal area is bounded posterolaterally by occipital suture (ocs) and upper portion of ocular suture (os), by the clypeogenal suture (clpges) and ventrally by the pleurostomal suture (ps). Anteriorly it can be separated from the frons (Fr) by a hypothetical line connecting the antennefer (af) of the antennal socket (Asoc) with the anterior tentorial pit (at). Dorsally it extends upto the vertex (Vx). According to Zaka (1971) in *D. cucurbitae*, " the gena consists of two parts viz., an anterior part enclosed in between the frontogenal and ocular sutures and a ventral part below the eyes merging with the post gena on the posterior surface of the cranium.

(iii) Antennal sclerite (Figs.1 ; Asc) :-

The antennal sclerite is a narrow sclerotic part bounded by the antennal suture (as). The rim of the antennal sclerite is raised.

(iv) Ocular sclerite (Figs.1,3 ; Osc) :-

The narrow marginal strip surrounding the compound eye by the ocular suture (os) is known as the ocular sclrite.

3. Occiput (Figs.2,5 ; Oc) :-

Occiput is the area which occupies the space between the occipital (ocs) and post occipital (pos) sutures. In *E. appendigaster* the occiput is inverted 'U' shape, completely surrounding the post occiput (Poc) as recorded by Alam (1951). However, Snodgrass (1942), Mathur (1970) in P.indicus, Zaka (1971) and Mathur (1977) in U.pulchella have not recorded the occipital suture in their insects and therefore, it is difficult to differenciate the occiput from the gena.

4. Post occiput (Figs.2,5; Poc):-

The area of the posterior surface of the head capsule which dorsolaterally surrounds the foramen magnum (For) and bounded by the post occipital suture (pos) is known as the 'post occiput'(Poc). It is separated from the occiput (Oc) by a complete post occipital suture (pos). In A.proxima it is separated from the post occiput by an incomplete post occipital suture (Dhillon, 1966).

5. Post gena (Figs.2,5 ; Pge) :-

The ventral area of the occipital region is termed as 'post gena'(Pge). It is separated from the hypostoma (Hst) by the hypostomal suture (hs) and from the gena by the occipital suture (ocs) of its side. Starting from the posterior mandibular articulation as a narrow space it immediately widens. The post genal lobes (PgL) of the two sides approximated before the foramen magnum into a hypostomal bridge (HB). The occiput (Oc) plus the post gena (Pge) have been designated as the 'occipital arch' by

Duncan (1939) in V.pensylvanica, Rakshpal (1956) in G.africana and Thakare (1962) in G.bimaculatus as these two areas are not separated from each other by any suture. In A.proxima the post gena merges with the gena laterally due to the absence of occipital suture & ends ventrally by a portion of the ventral margin of the cranium (Dhillon, 1966)-.

6. Sub gena (Figs. 1,2,3,5) :-

The subgenal area is represented by its both the components i.e. the pleurostoma (Plst) and hypostoma (Hst).

(i) Pleurostoma (Figs.1,3; Plst) :-

The area which is surrounded by the pleurostomal suture (ps) and the articular line of the mandible with the cranium is known as the 'pleurostomal sclerite' or the 'pleurostoma' (Plst).

(ii) Hypostoma (Figs.2,5 ; Hst) :-

The area which is surrounded by the hypostomal suture (hs) is known as the 'hypostomal sclerite' or the 'hypostoma' (Hst). It is in the form of an inverted 'V' the two ends pointing towards the ventral margins of the head capsule . On the ventral margin of the foramen magnum (For) and in the middle, the hypostoma forms a 'hypostomal bridge' (HB). Duncan (1939) termed the hypostomal bridge as the 'postgenal bridge' as it chiefly consists of postgenal lobes. The hypostoma bears two concavities at its lateral margins which are the points of articulation of the two cardines of maxillae. Alam (1951) showed that the hypostomal bridge bears two knobs in the oral fossa which are the points of articulations of the two cardines.

7. Foramen magnum (Figs.2,5 ; For) :-

The central area of the posterior surface of the head is perforated by the foramen magnum (For). It is completely divided into two unequal halves by a tentorial bridge (TB) which runs from one posterior tentorial pit (pt) to the another posterior tentorial pit. The dorsal half is comparatively larger than the ventral half..The former provides passage to the alimentary canal and the heart while the latter to the salivary duct and ventral nerve cord. On the lateral sides the rim of the foramen magnum (Rifor) bears a pair of concavities for the articulations of the pleurites of the prothorax as recorded by Alam (1951) and Dhillon (1966).

8. Oral fossa (Fig.2;OF) :-

The 'V'shaped ventral portion of the posterior surface of the cranium forms the 'oral fossa'(OF). The upper margin of the oral fossa is formed by the ventral limits of the hypostomal bridge (HB) while the lateral limits are formed by the hypostoma (Hst). The fossa provides articulation to the gnathal appendages.

TENTORIUM

(Figs.4,5;Tnt)

Tentorium is the endoskeleton of the insect cranium. It consists of anterior (AT), posterior (PT) and dorsal (DT) tentorial arms, the first two forming the tentorial bar (Alam,1951). Each bar is well sclerotised. The anterior tentorial arm arises from the anterior tentorial pit (at) and the posterior tentorial arm arises from the posterior tentorial pit (pt). Though it is impossible to limit the anterior and posterior tentorial arms due to the absence of any sign of demarcation between them, yet for the sake of convenience, the point of origin of the dorsal tentorial arm (DT) may be taken as the demarcating line of the anterior tentorial arm from the posterior tentorial arm. Thus, it can safely be said that the arm arising from the posterior tentorial pit upto the dorsal tentorial arm is posterior tentorial arm (PT) and the arm arising from the anterior tentorial pit and reaching upto the dorsal tentorial arm is anterior tentorial arm (AT).

The two tentorial bars bend inwards posteriorly and unite with each other forming a broad 'tentorial transverse bar'(tb). In other words the tentorial transverse bar is formed by the union of the mesal extensions of the anterior and posterior tentorial arms of either sides. This bar is formed by the fusion of the mesal extensions of the posterior tentorial arms in S.deesae (Alam,1951). Snodgrass (1942) in honey bee has shown it clearly in his figure (Fig.1,E) but has not given any name to it. Duncan (1939) in *V.pensylvanica* has not recorded any such bar. The ventral surface of the tentorial transverse bar posteriorly overlaps the hypostomal bridge (HB). The same condition has been observed by Snodgrass (1942) , Ferris (1950), Alam (1951), Dhillon (1966), and Zaka (1971).

Dorsally a tentorial bridge (TB) is also present which is in the form of a narrow, arched rod, connecting the two posterior tentorial pits and dividing the foramen magnum (For) completely into two unequal dorsal and ventral halves. In the middle of the tentorial bridge a stout , highly sclertized and spine like knob is present facing ventrally and giving attachment to the tendon of the 'ventral dilator of the anterior pharynx'(Figs.31,32;No.28).

The anterior tentorial arm has three sub divisions: a middle heavily sclerotized rod shaped portion and two semi sclerotic flaps known as mesal (mf) and lateral (lf) flaps of the anterior tentorial arm respectively as shown by Alam (1951) in *S.deesae* and Mathur (1977) in *U.pulchella* . These flaps have not been shown by Duncan (1939) in *V.pensylvanica* and Snodgrass (1942) in honey bee.

The dorsal tentorial arm (DT) is a long, sclerotic rod extending upto the base of the antennal socket (ASoc) and may be located on the cranial wall in the form of only external impressions. These impressions may be termed as the 'tentorial maculae'(dt) as shown by Snodgrass (1956) in honey bee and Dhillon (1966) in *A. proxima*.

Besides bracing the cranial wall, the tentorium provides attachment to the muscles of the maxillo-labial complex, antennae and pharynx. It also protects the cranium from stress and strain brought about on it by the working of muscles.

ANTENNA WITH ITS MUSCULATURE

(Figs.6-13;Ant)

The antennae (Ant) are situated slightly in the upper half and close to the middle on the facial wall of the cranium. Each antenna is filliform, long, many segmented and movable appendage of the head capsule. It is black in colour, covered with setae and attached with a membranous area on a slightly elevated rim which is known as the 'antennal socket' (ASoc).

Each antenna is divisible into two major parts as shown by Alam (1951) in S.deesae.

1. Basal stalk
2. Distal shaft

Basal stalk (Fig.6) :-

The basal stalk is composed of two segments. The proximal segment is ball like and has been termed as the 'bulb of the scape' (BlbSc) by Duncan (1939) in V.pensylvanica. Mathur (1970) in P.indicus call it as 'redicle.' The distal segment of the basal stalk is known as 'scape' (Sc). It is cylindrical and longest among all the antennal segments being narrower at its proximal end and broader at its distal end. At its distal end it is distended to encircle the proximal end of the pedicel (Pe). The proximal end of the bulb of scape has a deep concavity (Acon) and is placed completely within the antennal socket (ASoc). The antennal socket possesses an articular knob known as 'antennefer' (af) which articulates with the concavity on the bulb of the scape. This articulation is 'socket and ball' type.

Distal shaft (Fig.6):-

The distal shaft consists of two portions. (i) Pedicel (ii) Flagellum.

(i) Pedicel (Figs.6,9 ; Pe) :-

Pedicel is the shortest segment of antenna. It is the proximal most segment of the shaft. Actually it forms the pivot between the scape (Sc) and flagellum (Fl). The ddorsolateral angles of the pedicel have knob like structures which are termed as the 'articular knob' (ArkPe). The articular knobs of the proximal region of pedicel articulate with the articular knobs of the distal region of scape (ArkSc). This type of articulation has been termed as 'dicondylic' by Snodgrass.

(ii) Flagellum (Figs.6,8; Fl)

The second portion of the shaft is termed as flagellum. It is eleven segmented in both the sexes.

The basal segments of the flagellum are longer than the distal ones. All the segments af the flagellum are covered with very small and thin setae. Each segment of the flagellum has developed a convexity on its proximal end and a concavity on its distal end. The concavity of the distal end of one segment fits into the convexity of the proximal end of the preceding segment. Thus it is clear that the segments of the flagellum are not movably articulated.

Musculature of Antenna

Each antenna of E.appendigaster is provided by both the sets of muscles i.e. extrinsic and intrinsic.

Extrinsic muscles :-

The extrinsic muscles consist of four separate muscles inserted on the proximal rim of the bulb of scape (BlbSc). All of them have their origin on the anterior tentorial arm (AT). On the functional basis they have been distinguished as 'levators' and 'depressors'.

1. External levator (Figs.10,11 ; No.1) :-

The external levator originates from the dorsal surface of the anterior tentorial arm near the anterior tentorial pit (at). The tendon of this muscle is inserted on the dorsolateral angle of the proximal rim of the bulb of scape (BlbSc) very close to the articular concavity (Acon).

2. Internal levator (Figs,10,11 ; No.2) :-

This muscle originates from the mid dorsal region of the anterior tentorial arm. It is inserted by a tendon on the ventrolateral angle of the proximal rim of the bulb of scape away from the articular concavity.

3. External depressor (Figs.10,11 ; No.3) :-

This muscle originates from the dorsal surface of the corresponding anterior tentorial arm. The fibres of this muscle run close to the dorsal tentorial arm (DT). It is inserted through a tendon on the dorsal angle of the bulb of scape very close to the articular concavity.

4. Internal depressor (Figs.10,11 ; No.4) :-

It is a large muscle originating from the dorsal surface of the mesal region of the anterior tentorial arm. It ends on the dorsolateral angle of the proximal rim of the bulb of the scape away from the articular concavity.

A similar set of extrinsic muscles has been observed by Duncan (1939) in *V.pensylvanica*, Snodgrass (1942)in honey bee, Alam (1951) in *S.deesae* and Dhillon (1966) in *A.proxima*. However, in *A.proxima* the internal levator bears two bundles of muscle fibres and in *S.deesae*, the internal depressor has two bundles of muscle fibres. Mathur (1977) in *U.pulchella* has shown three sets of levators. Zaka (1971) in *D.cucurbitae* has observed extreme reduction in the extrinsic muscle by recording only one muscle known as 'rotator of antenna'.

Intrinsic muscles :-

There are two intrinsic muscles which control the movement of pedicel and flagellum.

1. Levator of flagellum (Fig.12;No.5) :-

This is a very long muscle arising concentrically from the inner dorsal arm of scape. It runs through the scape converging in the dorsal half of the proximal rim of pedicel. This muscle does not have any tendon.

2. Depressor of flagellum (Fig.13;No.6) :-

The depressor muscle originates from the inner surface and in the middle of scape and ends on the ventral portion of the proximal rim of pedicel. This muscle is also devoid of any distinct tendon.

These intrinsic muscles are homologous to the 'levator and depressors' of flagellum of S.deesae (Alam,1951),'levator and depressors' of pedicel of A.proxima (Dhillon,1966) and U.pulchella (Mathur,1977) and 'levator and depressor' of antenna of D.cucurbitae (Zaka,1971) and B.alami (Zaka,1978). Duncan (1939) has recorded no intrinsic muscles in V.pensylvanica.

LABRUM (Lm) AND EPIPHARYNX (Ephy)

(Figs.26,27,28,29,30,32)

Labrum (Lm) :-

Labrum is a small structure, hanging ventrally with the clypeus (Clp) at its lower edge with the help of a membrane known as labral hinge (Lmh). A similar suspension of the labrum with the clypeus has been recorded by Alam (1951) in S.deesae and Akbar (1957) in L.varicornis. However, the attachment line of clypeus with the labrum has been termed as 'labral suture' by Duncan (1939) in V.pensylvanica and 'clypeo-labral suture' by Rakshpal (1956) in G.africana and Thakare (1962) in G.bimaculatus. At the base near the attacment with the clypeus, the labrum is broad while it becomes narrower towards the distal region forming an elongate 'spatulate median process' (SLm), medially on its anterior surface which is clearly visible when the mandibles are opened. The base of the labrum is less sclerotized as compared with its median process. Similar median process has been reported by Duncan (1939) in V.pensylvanica. The tip of median process bears long and thick setae. The labrum is devoid of musculature.

Epipharynx (Ephy) :-

The epipharynx is nothing but a preoral outgrowth of the 'epipharyngeal surface' of the clypeus. It is a membranous fold arising just behind the labrum (Lm) and its base. The sides of the epipharynx form rounded wing like lobes that cover the angles of the mouth. Posteriorly the middle portion of the epipharynx is produced into a semi-crescent shaped tongue like fold which lies just behind the spatulate median process (SLm) of the labrum. Anteriorly the epipharynx is continuous with the pharynx. Between the lateral angles of the labrum and epipharynx on each side there is a small triangular heavily sclerotized sclerite which may be called as 'labral triangle'(LTr). Dhillon (1966) in A.proxima call it as torma. Each wing of the epipharynx contains in its posterior or ventral portion a slender, mesally tapering and weakly sclerotized strip which is known as epipharyngeal bar (EBa). Like labrum, the epipharynx is also devoid of musculature.

MANDIBLE WITH ITS MUSCULATURE

(Figs.1,3,14-17;Md)

The 'mandibles'(Md) of E.appendigaster are biting type and are highly sclerotized. They are hanged on the pleurostoma (Plst). The basal rim of each mandible (BrMd) has membranous connections with the pleurostoma. Anteriorly each mandible has a concavity (c) by which it articulates with the knob of the cranial wall. Posterioly it articulates with the concavity on the cranial wall with the help of a condyle which is developed at its outer basal angle. This condyle is known as the 'mandibular condyle'(MC). The occipital suture (ocs) of its side ends above the posterior mandibular articulation.

The mandible appears roughly triangular in shape. The apex of the mandible is black in colour, tapering and pointed. Each mandible may be divided into two parts. The anterior or distal part is known as the 'incisor area'(o) while the posterior or proximal part is termed as the 'molar area'(p). The incisor area is tridentate with outer teeth strongest and the inner teeth being shorter. The molar area is bidentate, the anterior tooth being longer than the posterior one.

More or less such type of well developed mandibles have been shown by Duncan (1939) in V.pensylvanica, Alam (1951) in A.proxima. Snodgrass (1942) in honey bee says that the shape and size of the mandible differs in all the three casts i.e. workers, drons and queens. Easthan and Essa (1955) observed reduced mandibles in *P.brassicae* where as Mathur (1977) showed the presence of vestigeal mandibles in *U.pulchella*. The mandibles are completely absent in *P.demoleus* (Vasudeva,1956 and Shrivastava,1957).

Musculature of the mandible :-

In *S.appendigaster*, each mandible is operated by two sets of extrinsic muscles; one enormous adductor muscle (No.7a,b) and a small abductor muscle (No.8).

(i) Adductor muscle (Figs.15,17;No.7a,b):-

The adductor muscle consists of two distinct branches. The inner and smaller branch (No.7a) originates on the vertex (Vx) near the lateral ocellus (LO). Its tendon is slender and rod like. The outer branch (No.7b) is very much stout, large and fan shaped originating from the lateral part of the vertex (Vx), dorsal part of the gena (Ge) and below and behind the eyes (E). Its tendon is broad and spatulate. The tendons of the two branches of adductor muscle unite to form a common tendon inserted on an apodeme (apd) which ends into a notch of the inner basal rim of the mandible near the anterior point of articulation (c). The contraction of the muscle moves the mandible towards the median axis bringing it close to its fellow of the other side. A more or less similar adductor muscle having two branches has been observed by Alam (1951) in *S.deesae* and Dhillon (1966) in *A.proxima*.

in honey bee (Snodgrass,1942) it bears several groups of muscle fibres. In H.graminicola (James,1926) the mandible has two sets of adductors where as in M.dentipes (Bucher,1948) and in U.pulchella (Mathur,1977) the adductor muscle is absent.

(ii) Abductor muscle (Figs.16,17; No.8) :-

The abductor muscle is relatively smaller than the adductor muscle. It is leaf shaped and made up of only one bundle of muscle fibres extending laterally on the dorsal part of the gena (Ge) reaching upto the vertex (Vx) and converging over the compound eyes (E). The tendon of this muscle ends posteriorly on the outer basal rim of the mandible near posterior mandibular articulation(a). This muscle is functionally antagonistic to adductor muscle. It moves the mandible away from the median axis carrying it away from its fellow of the other side. A similar muscle has been observed in V.pensylvanica (Duncan,1939), S.deesae (Alam,1951) and in A.proxima (Dhillon,1966). In H.graminicola (James,1926) and honey bee (Snodgrass,1942,56) the only abductor muscle bears two bundles of muscle fibres while in U.pulchella (Mathur,1977) it is totally wanting.

MAXILLO-LABIAL COMPLEX

(Fig.20)

As the name shows, the maxilla (Mx) and labium (Lb) have developed a complex organ by the fusion of the stipes (St) with the walls of the median cleft (mclf) of prementum (prmt) through a conjuctival membrane (Conj), except anteriorly where the membrane is replaced by a pivotal sclerite known as labio-maxillary jugum (LmJ). These two structures are corelated with each other in function. As they function like a single organ, the term 'maxillo-labial complex' has been used for them. However, Duncan (1939 in V.pensylvanica used the term 'labio-maxillary complex.' Snodgrass (1942) in honey bee , Alam (1951) in S.deesae and Dhillon (1966) in A.proxima call it as the maxillo-labial complex.

(a) MAXILLA

(Figs.18,19,20;Mx)

The maxillae (Mx) are of generalized type. They lie on either side of the labium (Lb) articulated with the latter. Each maxilla has the following major divisions.

Cardo (Figs.18,19,20;Cd) :-

The proximal, elongated and slender sclerite of maxilla is known as cardo (Cd). Its proximal end bears a single condyle (Cdc) by which it articulates with a concavity on the hypostoma (Hst). The two concavities are located dorsolaterally on the hypostoma, a condition also recorded by Duncan (1939) in

V.pensylvanica, Snodgrass (1942) in honey bee and Dhillon (1966) in A.proxima. Alam (1951) in S.deesae observed the two centrodorsally situated articular knobs on the hypostomal bridge (HB), responsible for the articulation of the cardines.

The cardo may be differenciated into two parts on the basis of sclerotization as shown by Alam (1951) in S.deesae and Mathur (1977) in V.pulchella. The heavily sclerotized part bearing the condyle may be termed as the 'outer cardo'(OCd) while the less sclerotized part attached with the stipes is termed as 'mesal cardo'(MCd).

Distally the cardo is continuous with the proximal margin of the stipes (St) through a hinge line known as the 'cardo-stipital hinge'(CdSth). It is the only line of demarcation between the cardo and stipes otherwise there is no other suture in between them. This hinge has been reffered as cardino-stipital hinge by Duncan (1939) in V.pensylvanica and stipito-cardinal hinge by Dhillon in A.proxima.

Stipes (Figs.18,19,20; St) :-

Distal to the cardo and beyond the cardo-stipital hinge the maxilla is continuous as stipes which is an elongated sclerite, roughly rectangular in shape,narrower at its proximal end and broader at its distal end. Its outer distal margin provides attachment to the base of the maxillary palpus (Mxplp). The distal half of the inner margin provides attachment to an inner lobe known as the 'lacinia'(Lc) while its extreme distal end gives attachment to the outer lobe known as 'galea'(Ga). The inner margin of the proximal half of stipes above the lacinia is attached with median cleft of the prementum (mclf) through a conjuctival membrane except distally where this membrane is replaced by labio-maxillary jugum (LmJ) forming the 'maxillo-labial complex.' Similar attachment of the maxilla (St) with the labium (Lb) has been recorded by Duncan (1939) in V.pensylvanica.

Lacinia (Figs.18,19,20 ; Lc) :-

Lacinia is the inner lobe of the stipes (St) and is attached with it on its inner distal half, mesal to galea (Ga). It is weakly sclerotized and is divisible into two parts. The upper part is completely fused with stipes, cylindrical and curved in shape. The flexors of lacinia (No.14) converge over its proximal end. The lower part of it is drawn out away from the stipes forming bluntly pointed projection, the latter bearing outwardly facing setae mesally.

Galea (Figs.18,19,20 ; Ga) :-

Galea is attached with the extreme distal end of the stipes and placed external to the lacinia. It is a broad and soft lobe, widened distally and having bulbous shape with long and thick setae on the distal portion.

<u>Maxillary palpus</u> (Figs.18,19,20 ; Mxplp) :-

The maxillary palpus arises laterad to the galea. Each palpus originates on the outer distal margin of the stipes. The palpifer is altogether lacking and the proximal segment of the palpus fits into a socket of the stipital wall. Each palpus consists of six segments, the proximal most being shortest one and the distal one being longest among all the palpal segments.

<u>Musculature of the maxilla</u>

The movement of the maxilla is controlled by extrinsic ass well as intrinsic muscles. The extrinsic muscles of maxilla also have their respective effect on the labium as these two structures (MxaLb) are corelated in function.

<u>Extrinsic muscles</u> :-

The following extrinsic muscles have been recorded in <u>E.appendigaster</u>.

(i) <u>Protractor of the cardo</u> (Figs.18,19, No.9) :-

It is a short and stout muscle originating just above the dorsolateral angles of the hypostoma (Hst) near the postgenal area (Pge) and very close to the post genal lobe (PgL) of its side. It converges over the outer margin of the cardo close to its articulation with the hypostoma. This muscle is comparable with the 'abductor of maxilla' in <u>Gryllus</u> (Duporte,1920), productor of cardo in <u>V.pensylvanica</u> (Duncan,1939), cardinal protractor of the proboscis' in honey bee (Snodgrass,1942,56) and 'first protractor of maxilla' in S.deesae (Alam,1951) and A.proxima (Dhillon,1966). These authors attributed the function of forward projection of maxilla to this muscle, but the present author is of the openion that this muscle also checks the displacement of maxilla at its basal articulation during the contraction of 'extensor muscle of maxilla.'

(ii) Extensor of the maxilla (Figs.18,19;No.10):-

It is a long and stout muscle the fibres of it originating on the ventral surface of the corresponding anterior tentorial arm (At) close to the anterior tentorial pit. It runs backwards reaching to the proximal tip of the stipes and ending near the cardo-stipital hinge line (CdSth). On contraction this muscle pulls the cardo to bring it in a straight line with the stipes consiquently protruding the whole maxilla forward and outward. This muscle is comparable with the 'extensor of maxilla' of V.pensylvanica (Duncan,1939), 'second protractor of maxilla' of S.deesae (Alam,1951) and A.proxima (Dhillon,1966).

(iii) Flexor of stipes (Figs.18,19 ; No.11):-

It is also a very stout and fan shaped muscle arising from the midventral surface of the proximal half of the corresponding anterior tentorial arm (AT) slightly in front of the dorsal tentorial arm (DT). This muscle is slightly posterior to the origin of the adductor muscle of the labium. The tendon of this muscle ends on the middle inner margin of the stipes. On contraction this muscle forces the stipes to bend on the cardo-stipital hinge. Alam (1951) and Dhillon (1966) call it as the 'flexor of maxilla.' This muscle has also been represented by Duncan (1939) and Snodgrass (1942).

(iv) Adductor of maxilla (Figs.18,19; No.12) :-

This is a short muscle originating on the anterior tentorial arm (AT) near the flexor of stipes (No.11). The tendon of this muscle ends very close to the tendon of stipes. Alam (1951) in S.deesae has shown a more or less similar muscle having a common tendon with the flexor of lacinia. He called it as 'second flexor of lacinia.' This muscle has not been recorded in V.pensylvanica (Duncan,1939), in A.proxima (Dhillon,1966) and in P.indicus (Mathur,1970).

Intrinsic muscles :-

The muscle originating and ending within the maxilla itself have been clustered in one group called 'intrinsic muscles' of maxilla. They are as follows:

(i) Flexor of galea (Fig.18,No. 13) :-

It originates from the distal half on the lateral wall of the stipes beneath the attachment of the tendon of flexor of stipes (No.11). Its fibres converge anteriorly on the base of galea. Its runs ventral to the 'flexor of lacinia'(No.14) and at right angle to it. A similar muscle has been shown by Duncan (1939) in V.pensylvanica . This muscle is also homologous to the 'flexor of galea' of _S. deesae_ (Alam, 1951) and _A. proxima_ (Dhillon, 1966). It also corresponds to the 'flexor of galea' of honey bee (Snodgrass, 1942) and _P. indicus_ (Mathur, 1970).

(ii) Flexor of lacinia (Fig. 18; No.14) :-

It is a fan shaped muscle, the fibres of which originating on the outer margin of stipes, running dorsal to all the intrinsic muscles and converging to end at the base of lacinia.

(iii) Depressor of maxillary palpus (Fig. 18 ;No.15) :-

This muscle arises from the proximal part of the stipes, its fibres spreading upto the 'adductor of maxilla' (No.12). It is internal to the 'flexor of the lacinia' (No.14). The tendon of this muscle ends on the basal rim of the palpus. This muscle controls the movements of the palpus. Duncan (1939) in _V. pensylvanica_ and Alam (1951) in _S. deesae_ observed two muscles of each palpus namely 'anterior and posterior depressor.' Dhillon (1966) in _A. proxima_ recorded one 'levator' and one 'depressor' of each palpus.

(iv) Flexor of the maxillary palpus (Fig.18 ; Nos.16a,b,c.):-

The first three segments of each palpus are provided each with an unpaired small flexor muscle. The fibres of each muscle converge to form a tendon which ends on the proximal rim of the preceeding segment. Similar flexor muscles have been shown by Alam (1951) and Dhillon (1966) however, Duncan (1939) and

Snodgrass (1942) failed to observe any such muscle.

(b) LABIUM

(Figs.20-24 ; Lb)

The labium (Lb) possesses all the parts found in a generalized insect except the 'post labium.' The pre labium (PrLb) is well developed. It is represented by a central body , called the 'prementum'(Prmt) bearing the 'glossa'(Gl),'paraglossa'(Pgl) and 'labial palpi'(Lb,lp). The prementum (Prmt) hangs ventrally and vertically in the oral fossa (OF) from the margin of hypostoma (Hst) through a connecting membrane. The present observation is in accordance with Duncan (1939) in *V.pensylvanica* and Alam (1951) in *S.deesae*.

Prementum (Figs.20,21,22,23 ; Prmt) :-

The prementum is well developed and single undivided plate, occupying almost whole of the area of the labium. It consists of dorsal and ventral walls confluent along anterior and lateral margins. The ventral wall is flat and heavily sclerotized and the dorsal wall is less sclerotized. Two dorsolateral sides of the prementum are raised upwards forming a wide space in between them which is known as 'median cleft' (mclf). Anteriorly the median cleft is roofed over by hypopharynx. The median cleft provides a passage for various muscles of the labium while its walls give attachment to the maxilla (Mx) by means of a broad strip of membrane except anteriorly where the membrane is largely replaced by a pivotal sclerite which is called as the 'labio-maxillary jugum'(LmJ). The outer margin of the jugum articulates with the stipes while its inner margins articulates with the prementum. A well developed labio-maxillary jugum has been observed by Duncan (1939) in *V.pensylvanica*. However, Snodgrass (1942) in honey bee, Alam (1951) in *S.deesae* and Dhillon (1966) in *A.proxima* failed to obseve any such jugum between maxilla and labium.

Lobes of the prementum :-

Distally in between the labial palpi (Lbplp) the prementum bears the 'ligula'(lig). On its posterior surface the ligula is undivided but anteriorly it is differenciated into two lobes, a large median lobe called the 'lingua'(Lin) and a pair of lateral lobes called 'paraglossa'(Pgl). The lingua is further divided anteriorly by a deep notch into two lobes known as 'glossae'(Gl).

(i) Glossa (Figs.20,21,22,23 ; Gl) :-

Apically the lingua (Lin) is divided into two divisions by a deep notch. These divisions may be termed as the 'glossae as shown by Duncan (1939) in *V.pensylvanica*. However, Alam (1951) in *S.deesae* has the openion that the presence of only a notch in between the lingua is not a sufficient proof for the presence of glossa. Each glosse is membranous in nature. The tip of each glossa bears cuticular thickenings which has been named as 'acroglossal button'(AcB) by Duncan (1939) in V.pensylvanica. Alam (1951) and Duncan (1939) respectively observed 'anterior and posterior lingual plates' but the present writer failed to observe any such sclerite in E.appendigaster. He also did not find any 'lingual hinge plate' as has been shown by Duncan (1939).

(ii) Paraglossa (Figs.20,21,22,23 ; Pgl):-

On either sides of the glossa there is a pair of 'paraglossa'(Pgl). They are membranous in nature. Each paraglossa has two distinct parts viz. 'basal sclerite'(BsPgl) and the 'body of paraglossa'(BPgl). The basal sclerite is some what oval in shape while the body of paraglossa is cylindrical, long and rod like. Setae are also present on whole of the basal sclerite and on the tip of the body of paraglossa which are grasping in function.

Dhillon (1966) in A.proxima has shown a median undivided glossa and two lateral paraglossa. However, Mathur (1977) did not find these two structures in V.pulchella . The labium in this case is trifid and is fused with hypopharynx. Snodgrass (1942) in honey bee observed a pair of short lateral paraglossae and a long median tongue which according to him is combined glossa.

(iii) Labial palpi (Figs.20,21,22,23;Lbplp):-

The prementum bears distally at its lateral angles a pair of labial palpi. Snodgrass (1942) in honey bee and

Dhillon (1966) in A.proxima showed the presence of a pair of 'palpigers' which carry labial palpi but in the present case the palpigers are completely absent. The base of each palpus is suspended by its inner margin from the tip of a slender process of the prementum. Each palpus is four segmented, the fourth one being largest while the third one being shortest. The third segment is more or less oval in shape while the first, second and fourth segments are long and roughly cylindrical.

Musculature of the Labium

The movements of the labium are brought about by both extrinsic as well as intrinsic muscles. The extrinsic muscles of labium also control the movements of the maxillae.

A. Extrinsic muscles :-

The extrinsic muscles are represented by a pair of 'adductors of labium' and a pair of 'flexors of paraglossae'.

1. Adductors of labium (Figs.23,24;No.17) :-

The adductors of labium are long and fan shaped muscles, the fibres of which originate from the ventral surface of the mesal proximal half of the anterior tentorial arm (AT) close to the origin of the flexor of stipes (No.11) and converge downwards into a tendon. The tendons of the two adductors unite to form a short 'common tendon' which is attached on the mid proximal edge of the ventral wall of the prementum. The adductor along the flexors of stipes and the extensors of maxillae (No.10) move the maxillo-labial complex. A similar muscle has been shown by Duncan (1939) in V.pensylvanica and Dhillon (1966) in A.proxima. This muscle is also homologous with the 'posterior adductor of labium' shown by Snodgrass (1942) in honey bee and Alam (1951) in S.deesae. Alam (1951) also observed a pair of 'levator muscle'. Mathur (1977) in U.pulchella did not found any extrinsic muscle.

2. Flexors of paraglossa (Figs.23,24 ; No.18) :-

They are largest muscles of the labium, originating on the posterior cranial wall dorsolateral of the posterior tentorial arms (PT), running the whole length of the labium in between the median cleft, reaching upto the paraglossa (Pgl) and ending on its basal sclerite. A similar muscle has been observed by Duncan (1939). This muscle is homologous with the 'anterior adductor of labium' of Snodgrass (1942), Alam (1951) and Rakshpal (1956).

B. Intrinsic muscle :-

The intrinsic muscles of labium consist of a pair of 'posterior flexor of ligula' (No.19), a pair of 'anterior flexor of ligula' (No. 20), a pair of 'adductors of labial palpi' (No.21) and a pair of 'flexors of palpal segments' (No.22).

1. Posterior flexor of ligula (Fig.22;No.19) :-

A pair of posterior flexors of ligula arises in between the median cleft running through its lateral walls and converging on the base of glossa (Gl). This muscle is homologous with the 'flexors of lingua' of S.deesae (Alam,1951), the 'flexors of the tongue' of honey bee (Snodgrass,1956) and the 'flexors of glossa' of A.proxima (Dhillon,1966). Duncan (1939) in V.pensylvanica has shown an unpaired 'posterior flexor of ligula.'

2. Anterior flexors of ligula (Fig.22; No.20) :-

It is a pair of long muscles arising on the proximal region of the prementum, running through the lateral walls of the median cleft and ending on the basal sclerite of the paraglossa (BsPgl). This muscle is homologous with the 'anterior flexor of ligula' of V.pensylvanica (Duncan,1939). It is also comparable with the 'premental retractor of ligula' of honey bee (Snodgrass,1942), the 'ligular flexor' of S.deesae (Alam.1951) and the 'flexors of paraglossa' of A.proxima (Dhillon,1966).

3. Adductors of labial palpi (Fig. 22;No.21) :-

Each palpus is provided by a muscle at its base which originates with in the median cleft from the proximal half of the prementum. The fibres of this muscle converge over the basal rim of the proximal most segment of the palpus. Duncan (1939) in his insect call it as the 'depressor of the labial palpus' where as, Alam (1951) named it as the 'flexor of labial palpus' and Mathur (1977) in U.pulchella as the 'levator of palpus.'

4. ***Flexors of labial palpi*** (Fig.22;No.22):-

Each palpus is provided by two flexors with in the basal segments, the first flexor ending at the base of the succeeding segment while the second one originating from the basal portion of second segment and ending at the base of the third segment. The apical segment can not move independently. A similar pair of flexors has been shown by Alam (1951), Dhillon (1966) and Mathur (1970). Snodgrass (1942) in honey bee observed only one such muscle where as Duncan (1939) has not mentioned about them.

(C) HYPOPHARYNX

(Figs.25,30,32;Hphy)

With in the pre-oral cavity (Prc) and behind the mouth (Mth) the dorsal surface of the prementum (Prmt) is roofed over by the 'hypopharynx'(Hphy). It includes an 'oral plate'(opl) on the floor of the mouth cavity and a bib like 'fold'(bib) that hangs down from the margin of the plate anteriorly. Posteriorly the oral plate is continuous into two lateral walls (WHphy) and a median lobe which has been termed as 'salivos' by Rakshpal (1954) in G.africana. The anterior surface of the hypopharynx is less sclerotic in comparision to the posterior one and bears laterally two rod like and heavily sclerotized sclerites which are known as 'suspensorial bars'(HS). These bars not only provide suspension to the hypopharynx but also help in maintaining its shape. Along each wall of hypopharynx runs a band like sclerite which is moderately sclerotized & bears a comb like row of long, stiff, medially directed and appressed setae which are known as 'hypopharyngeal pectin'(HyP).

Musculature of Hypopharynx

1. Dilators of salivarium (Fig.32;No.23a,b) :-

There are two pairs of 'dilators of salivarium' arising from the lateral walls in the median cleft (mclf) of the prementum (Prmt). The fibres of these muscles do not end in any tendon but they directly end on the wall of the salivarium (slv).

2. Compressors of salivarium (Fig.25;No.24) :-

There is a pair of 'compressors of salivarium.' Each of them arises with in the median cleft and ends on the lateral walls of the hypopharynx. On contraction these muscles pull down the lateral walls of the hypopharynx and consequently the fold (bib) is pulled downward thus exerting the pressure on the salivarium. This muscle brings about reduction in volume along with the relaxation of the dilators (No.23a,b)and in this way the salivarium is compressed and saliva is ejected.

3. Retractor of the mouth angles (Fig.25;No.25a,b) :-

These consist of two pairs of muscles originating on the frons and ending on the proximal portion of the lateral walls of the hypopharynx. The contraction of these muscles pulls the

the hypopharynx forward and upward and it is this movement of hypopharynx that forces the food from the cibarium through the mouth into the buccal region of the stomodaeum.

The preoral Cavity

(Fig.32 ; Prc)

The gnathal appendages are situated close to each other e enclosing a space between them and in front of true mouth, which is called the 'preoral cavity'(Prc). It is bounded anteriorly by the epipharyngeal wall of the labrum (Lm) and clypeus (Clp), posteriorly by the labium (Lb) and laterally by the mandibles (Md) and maxillae (Mx). With in the preoral cavity lies the hypopharynx (Hphy) forming the roof of the median cleft (mclf) of the prementum (prmt). The true mouth (Mth) is located behind the preoral cavity at the level of the labral hinge (Lmh) and in front of the hypopharynx and is laterally concealed between the bases of the mandibles. The opening of the salivary duct (SlO) is situated in the middle at the posterior end of the hypopharynx at the base of prementum. The food meatus (fm) is situated in between the hypopharynx and the epipharyngeal wall of the labrum and clypeus anteriorly and laterally. Posteriorly in between the hypopharynx and the labium there is salivary meatus (sm) at the inner end of which is the opening of the salivary duct. The upper or inner part of the food meatus forms the preoral food chamber which may be termed as 'cibarium'(cb). The floor of the cibarium is formed by the base of hypopharynx flanked by its suspensorial bars, while the roof of the cibarium is formed by the epipharyngeal surface of the clypeus. Likewise , the salivary meatus terminates in the salivary pocket which may be termed as 'salivarium'(slv). The floor of the salivarium is formed by the dorsal wall of the prementum where as its roof is formed by the ventral wall of the hypopharynx. The duct of the salivary gland (SlD) opens into the salivarium.

Cephalic Stomodaeum with its Musculature

(Fig.28,29,30,31,32)

The part of the fore gut with in the head capsule is known as the 'cephalic stomodaeum.' It passes into the thorax through the upper (dorsal) half of the foramen magnum (For). It is embraced by the nerve connectives from the brain (Br) to the sub oesophageal ganglion (SoeGng); the frontal ganglion (FrGng) lies on its dorsal wall anterior to the brain. The first part of the stomodaeum lies immediately with in the mouth (Mth) and may be termed as buccal cavity (Buc). Following the buccal cavity posterior to the true mouth is the region of the pharynx (Phy). The pharynx may be divisible into two: the post cerebral pharynx is termed as 'posterior pharynx'(PPhy) and the precerebral pharynx is termed as 'anterior pharynx'(Aphy). The anterior pharynx is broader than the posterior pharynx. It has a form of broad flattened pocket extending anteriorly from the mouth for a short distance then turning upward narrowing in its upper half and reaching upto the level of antennal sockets (Asoc) where it is continuous with the posterior pharynx. The anterior pharyngeal wall is less sclerotized than the posterior pharyngeal wall. A large plate known as the 'pharyngeal plate'(PhPl) is developed in the posterior wall from the dorsolateral angles of which arises a pair of rods known as the 'dorsal pharyngeal bar'(DPhB). The pharyngeal plate and the dorsal pharyngeal bars keep the anterior pharynx wide spread and flattened.

A shorter pair of processes known as the 'ventral pharyngeal bar'(VPhB) also extend from the ventrolateral angles of the pharyngeal plate downward to the angles of the mouth. The posterior pharynx passes below the brain and is followed by oesophagous (Oe). It is more or less equal to the oesophagous in diameter.

Musculature of the Cepalic Stomodaeum

The muscles of the cephalic stomodaeum are paired as well as unpaired. Some originate on the frons and some on the clypeus. These muscles are as follows :

1. First frontal dilator of anterior pharynx (Figs.28,29,30,32;No.26):-

These are a pair of long and stout muscles originating in flattened ellipses on the frons and inserting on the proximal portion of the dorsal pharyngeal bars of the anterior wall of pharynx just behind the frontal ganglion.

2. Second frontal dilators of anterior pharynx (Figs.28,29,30,32;No.27):-

Single paired longer and thicker than the first dilators, the second frontal dilators originate on the frons near the antennal bases close to the first dilators of anterior pharynx. The fibres of these muscles end on the proximal portion of the dorsal pharyngeal bars of the anterior phatynx. There are three pairs of frontal dilators in S.deesae (Alam,1951) and A.proxima (Dhillon,1966) and two pairs in honey bee (Snodgrass,1942) and P.indicus (Mathur,1970).

3. Ventral dilator of the anterior pharynx (Figs.31,32,;No.28):-

It is an unpaired muscle originating from the knob of the tentorial bridge (KTB) having a long tendon. The fibres of this muscle end on the ventral surface of the anterior pharynx. This muscle is equavalent to the 'posterior dilator of the anterior pharynx' of V.pensylvanica (Duncan,1939), Second ventral dilator of the anterior pharynx' of S.deesae (Alam,1951) and 'ventral dilator of the anterior pharynx' of P.indicus (Mathur,1970).

4. Lateral pharyngeal muscles (Figs.28;No.29) :-

It is a pair of slender muscles of uncertain homology originating alongside the ventrolateral angles of the clypeus and inserted on the upper ends of dorsal pharyngeal bars. On contraction these muscles spread the bars.

5. Dorsal dilator of the food meatus (Figs.28,30,32;No.30):-

This muscle is short and unpaired. It originates in a linear manner on the clypeus and inserted on the pharyngeal plate of the anterior pharyngeal wall ending without any tendon. On contraction it widens the opening.

6. Anterior intrinsic pharyngeal muscle (Fig.28;No.31) :-

It is a mass of intrinsic muscle fibres extending transversely on the anterior pharyngeal wall in between the dorsal pharyngeal bars.

7. Pharyngeal dilator of the mouth (Fig.29;No.32) :-

They are a pair of large intrinsic muscles on the posterolateral portions of the pharyngeal plate curving forward and mesally over the anterior surface of the pharynx and insertingon on the anterior pharyngeal wall close to the mouth and alongside the dorsal dilator of the food meatus.

8. <u>Dorsal dilator of the cibarium</u> (Fig.32;No.33a,b) :-

These are two pairs of stout dilator muscles arising close to each other on the clypeus. These muscles end on the dorsal wall of the cibarium along its mid longitudinal area.

9. <u>Compressor of anterior pharynx</u> (Figs.28,29; No.34) :-

The pharyngeal plate is enveloped throughout in a layer of circular muscle fibres which are responsible for the compression of anterior pharynx.

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ABBREVIATIONS USED

a	:	Posterior mandibular articulation
af	:	Antennefer
apd	:	Apodeme
as	:	Antennal suture
at	:	Anterior tentorial pit
AcB	:	Acroglossal button
Acon	:	Articular concavity
Ant	:	Antenna
APhy	:	Anterior pharynx
ArkPe	:	Articular knob of the pedicel
ArkSc	:	Articular knob of the Scape
ASc	:	Antennal sclerite
ASoc	:	Antennal socket
AT	:	Anterior tentorial arm
bib	:	bib like fold of hypopharynx
BlbSc	:	Bulb of the scape
BPgl	:	Body of the paraglossa
Br	:	Brain
BrMd	:	Basal rim of the mandible
BsPgl	:	Basal sclerite of the paraglossa
BuC	:	Buccal cavity
c	:	Anterior mandibular articulation
cb	:	Cibarium

clpges : Clepeogenal suture

cs : Epicranial suture

Cd : Cardo

CdC : Cardinal condyle

CdSth : Cardo stipital hinge

Clp : Clypeus

Conj : Conjuctival membrane

CTnd : Common tendon

dt : Tentorial macula

DdrSc : Dorsal part of the distal rim of scape

DPhB : Dorsal pharyngeal bar

DPrPe : Dorsal part of the proximal rim of pedicel

DT : Dorsal tentorial arm

E : Compound eye

EBa : Epipharyngeal bar

Ephy : Epipharynx

fm : Food meatus

Fl : Flagellum

For : Foramen magnum

Fr : Frons

FrClp : Frontoclypeus

FrGng : Frontal ganglion

Ga : Galea

Ge : Gena

Gl : Glossa

hs	:	Hypostomal suture
HB	:	Hypostomal bridge
Hphy	:	Hypopharynx
Hst	:	Hypostoma
HyP	:	Hypopharyngeal pectin
KTB	:	Knob of the tentorial bridge
lf	:	Lateral flap of the anterior tentorial arm
Lb	:	Labium
Lbplp	:	Labial palpus
Lc	:	Lacinia
Lig	:	Ligula
Lin	:	Lingua
Lm	:	Labrum
Lmh	:	Labral hinge
LmJ	:	Labio-maxillary jugum
LO	:	Lateral ocellus
LTr	:	Labral triangle
mclf	:	Median cleft of the prementum
mf	:	Mesal flap of the anterior tentorial arm
MC	:	Mandibular condyle
MCd	:	Mesal cardo
Md	:	Mandible

MC	:	Median ocellus
Mth	:	True mouth
Mx	:	Maxilla
Mx plp	:	Maxillary palpus
o	:	Incisor area
ocs	:	Occipital suture
opl	:	Oral plate of hypopharynx
os	:	Ocular suture
Oc	:	Occiput
OCd	:	Outer cardo
Oe	:	Oesophagus
OF	:	Oral fossa
OSc	:	Ocular sclerite
p	:	Molar area
pos	:	Post occipital suture
prSc	:	Proximal rim of scape
ps	:	Pleurostomal suture
pt	:	posterior tentorial pit
pe	:	pedicel
pge	:	post genal area
pgl	:	Paraglossa
pgL	:	Post genal lobe
PhPl	:	Pharyngeal plate
Phy	:	Pharynx

Plst	:	Pleurostoma
Poc	:	Post occiput
Pphy	:	Posterior pharynx
Prc	:	Preoral cavity
PrLb	:	Pre labium
Prmt	:	Prementum
Prtl	:	Parital
PT	:	Posterior tentorial arm
rf	:	Roof of the hypopharynx
RiFor	:	Rim of foramen magnum
sgs	:	Sub genal suture
sl	:	Salivos
slv	:	Salivarium
sm	:	Salivary meatus
Sc	:	Scape
SlD	:	Salivary duct
SlO	:	Opening of the salivary duct
SLm	:	Spatulate median process of the labrum
SoeGng	:	Sub oesophageal ganglion
St	:	Stipes
tb	:	Tentorial transverse bar
TB	:	Tentorial bridge
Tnt	:	Tentorium
To	:	Tooth of incisor area
Tp	:	Tooth of molar area

vdrSc	:	Ventral part of distal rim of scape
VphB	:	Ventral pharyngeal bar
Vx	:	Vertex
WHphy	:	Lateral Wall of the hypopharynx

EXPLANATION OF FIGURES

PLATE I

Fig. No. 1. Anterior view of the head capsule

Fig. No. 2. Posterior view of the head capsule

PLATE I

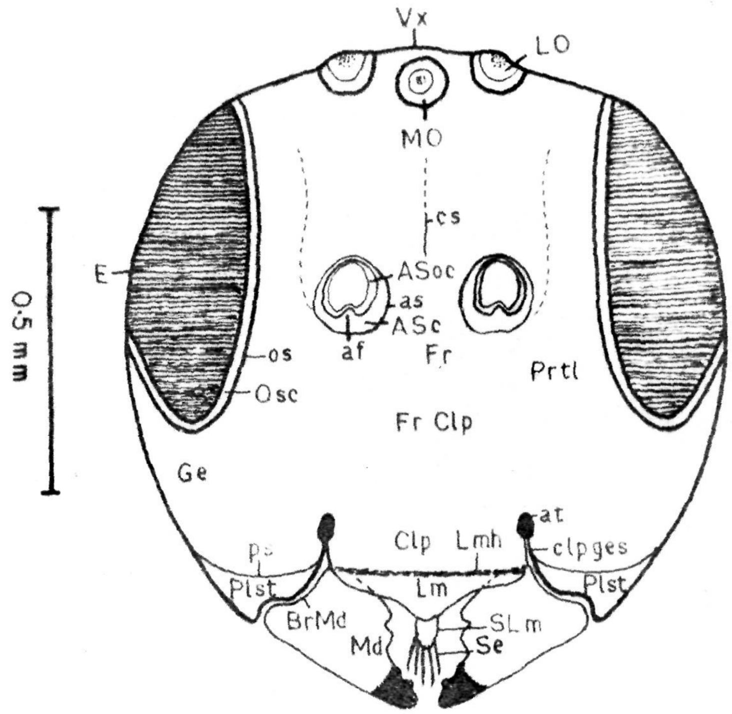

FIG. 1

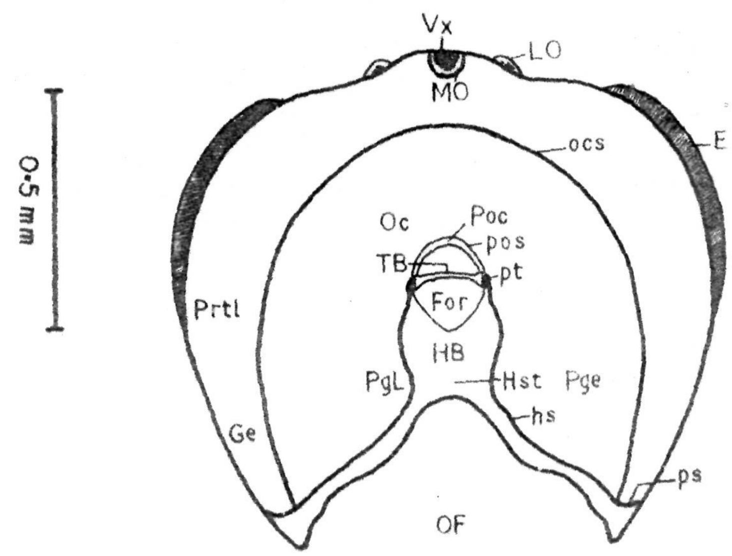

FIG. 2

PLATE II

Fig. No. 3. Lateral view of the head capsule

Fig. No. 4. Posterior view of the tentorium

Fig. No. 5. Location of the tentorium on the head capsule

PLATE II

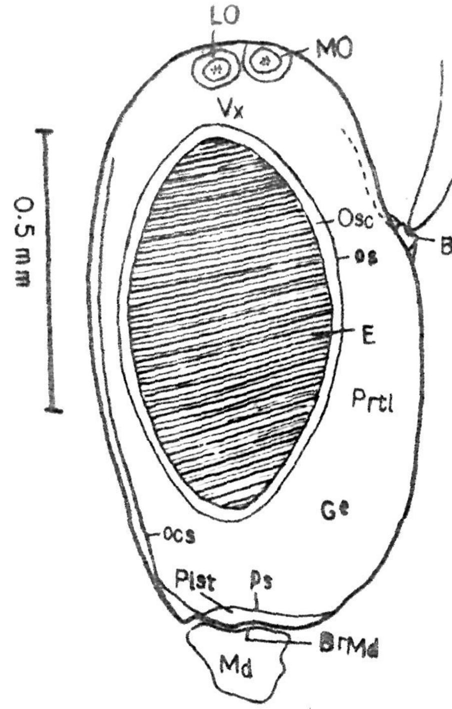

FIG. 3

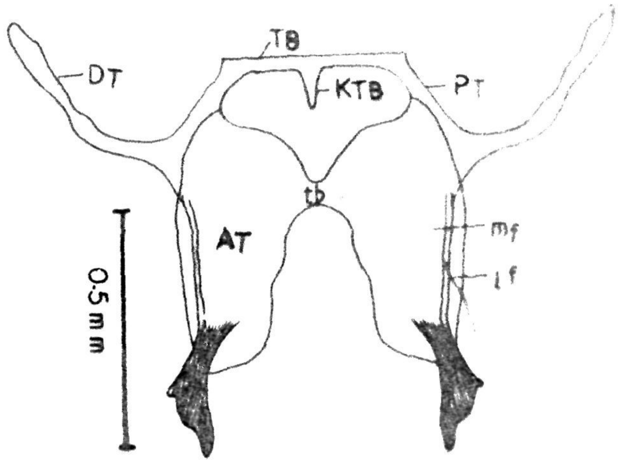

FIG. 4

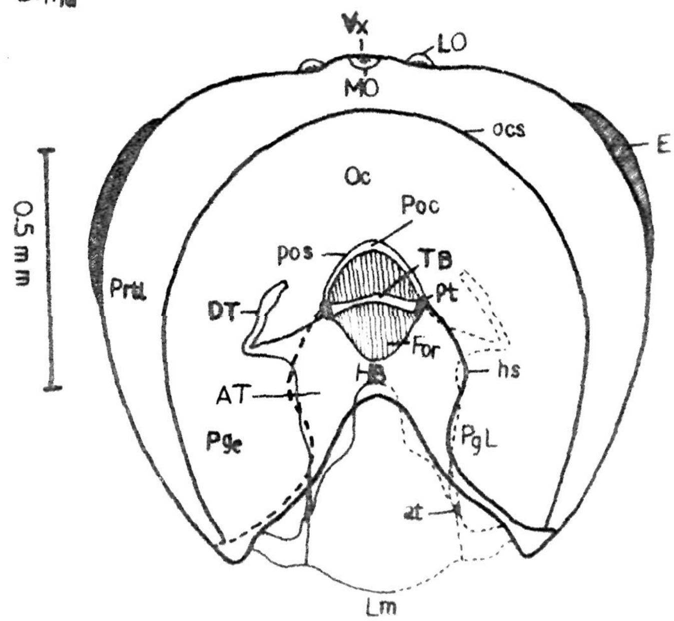

FIG. 5

PLATE III

Fig. No. 6. Antenna

Fig. No. 7. Antennal articulation with antennal socket

Fig. No. 8. Articulation of the two segments of flagellum with each other.

Fig. No. 9. Scapo-pedicellar articulation

Fig. No. 10. Basal rim of the bulb of scape with muscles

Fig. No. 11. Antennal extrinsic muscles showing their origin from the tentorium

Fig. No. 12. Depressor of flagellum

Fig. No. 13. Levator of flagellum

PLATE III

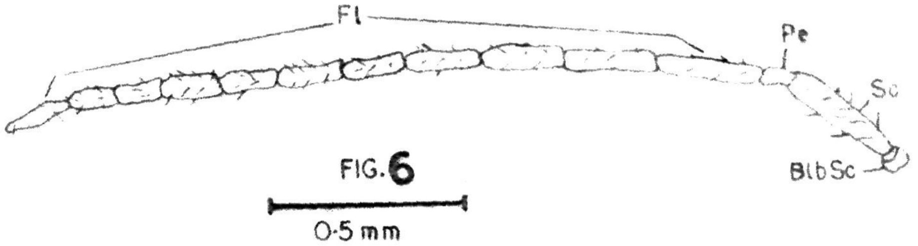

FIG. 6

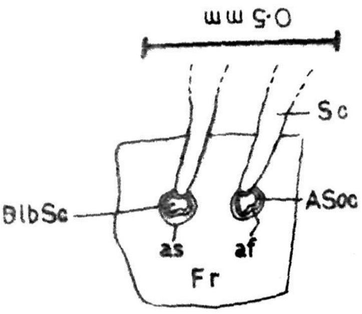

FIG. 7

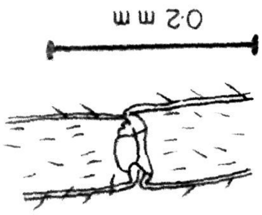

FIG. 8

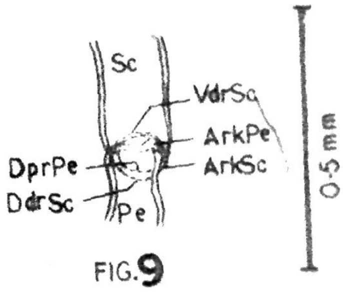

FIG. 9

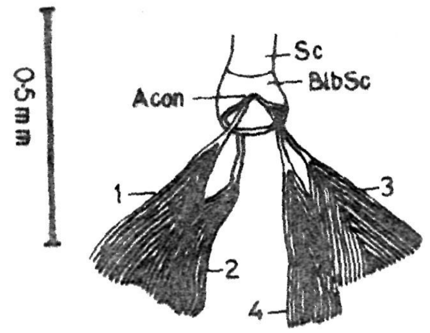

FIG. 10

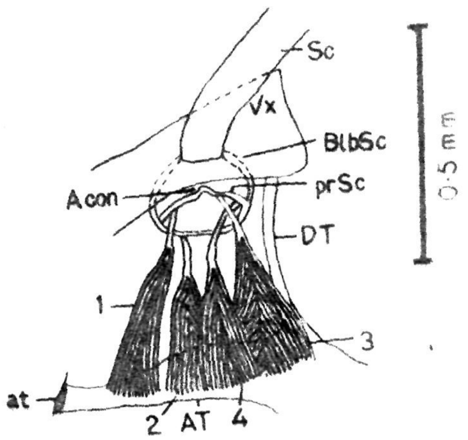

FIG. 11

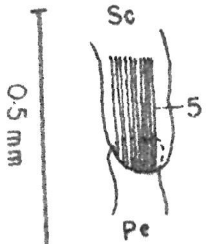

FIG. 12

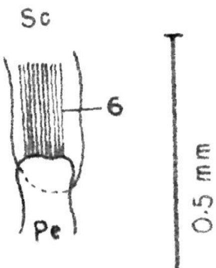

FIG. 13

PLATE IV

Fig. No. 14. Mandible

Fig. No. 15. Mandibles with its muscles in relation to cranium

Fig. No. 16. Mandible with its adductor muscle

Fig. No. 17. Mandible with its abductor muscle

PLATE IV

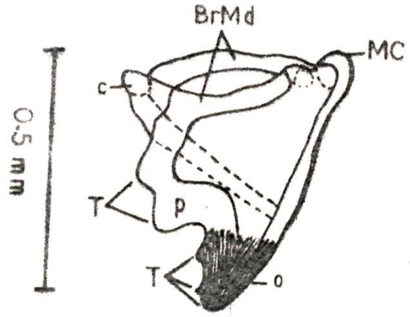

FIG. 14

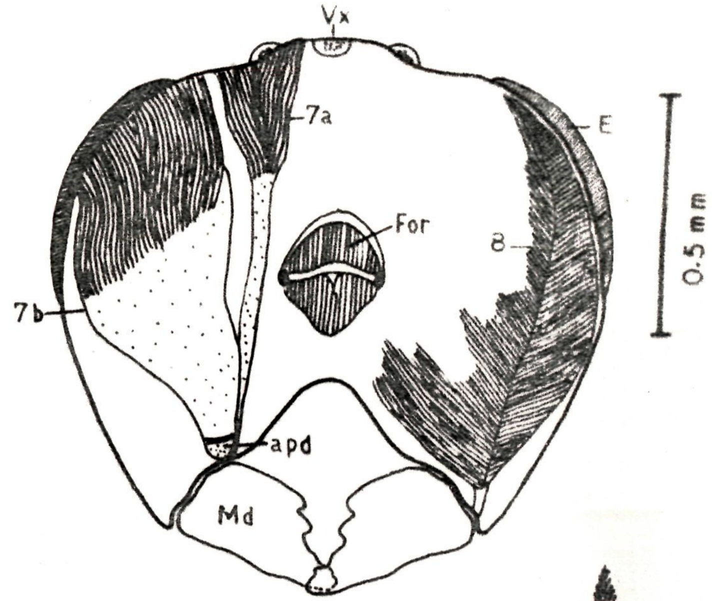

FIG. 15

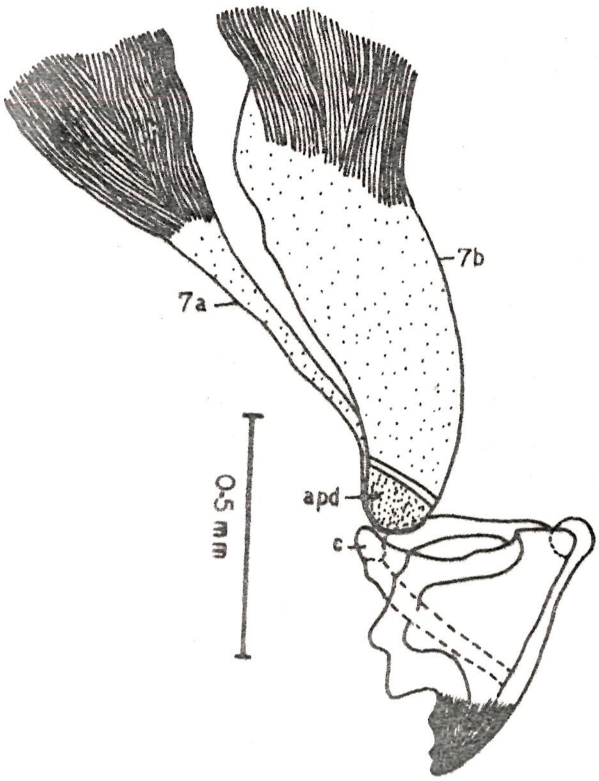

FIG. 16

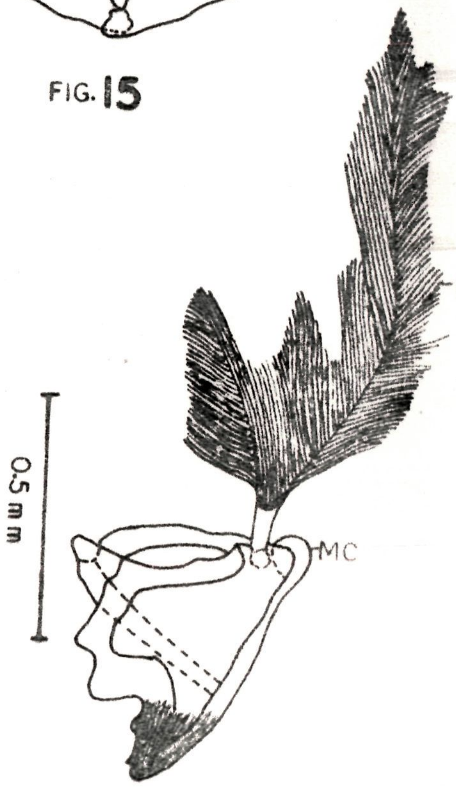

FIG. 17

PLATE V

Fig. No. 18. Dorsal view of Maxilla with its musculature

Fig. No. 19. Extrinsic muscles of maxilla showing their origin.

PLATE V

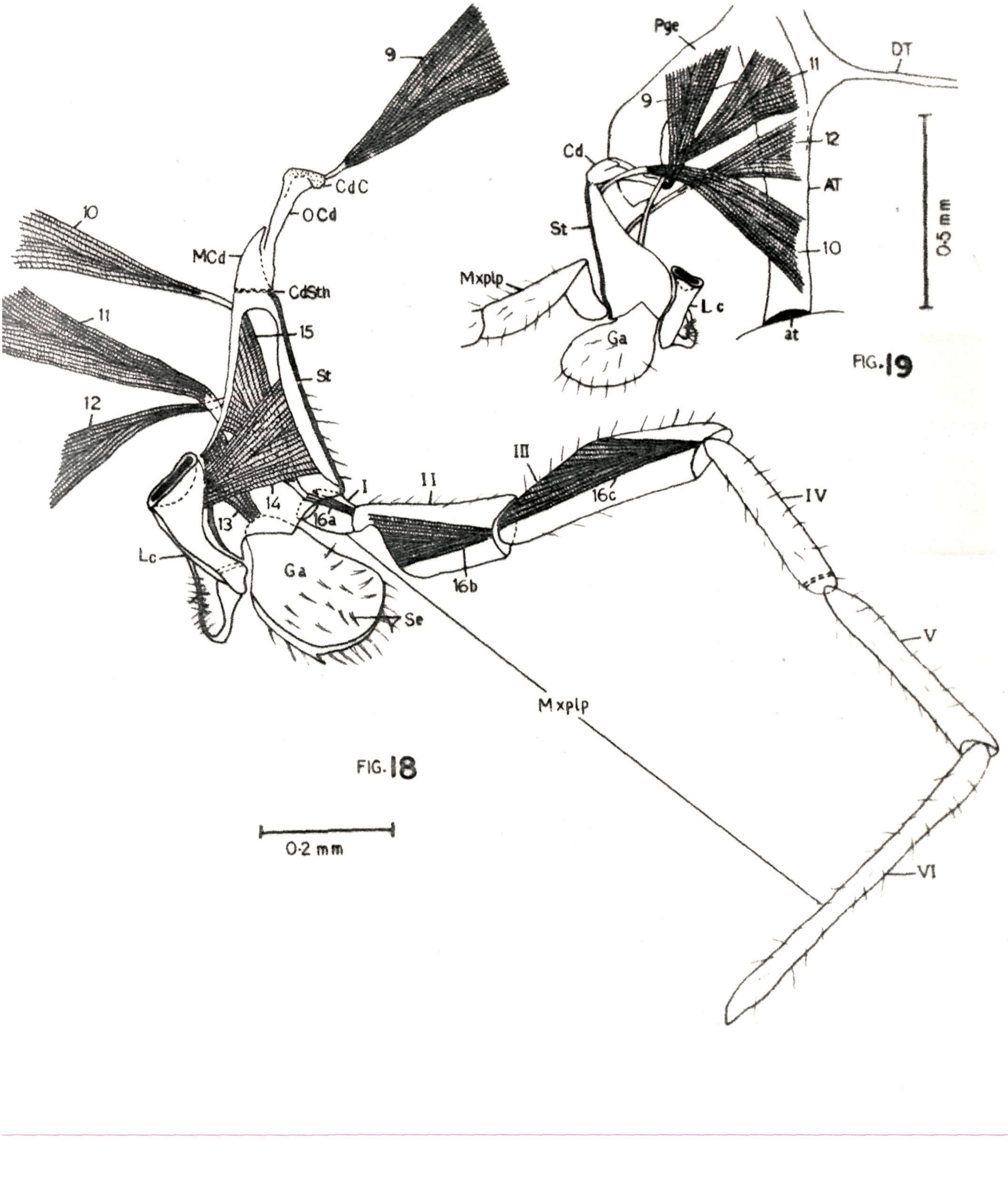

FIG. 19

FIG. 18

PLATE VI

Fig. No. 20. Dorsal view of maxillo-labial complex

Fig. No. 21. Dorsal view of prementum showing labio-maxillary jugum

Fig. No. 22. Dorsal view of labium showing its intrinsic muscles

Fig. No. 23. Dorsal view of labium showing its extrinsic muscles

Fig. No. 24. Extrinsic muscles of labium showing their origin from the tentorium

PLATE VI

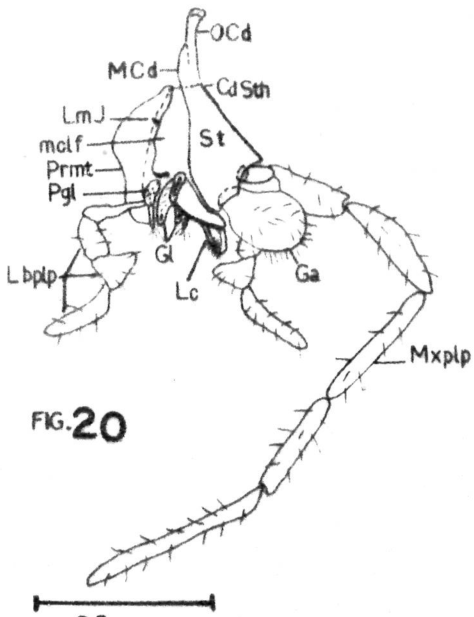

FIG. 20

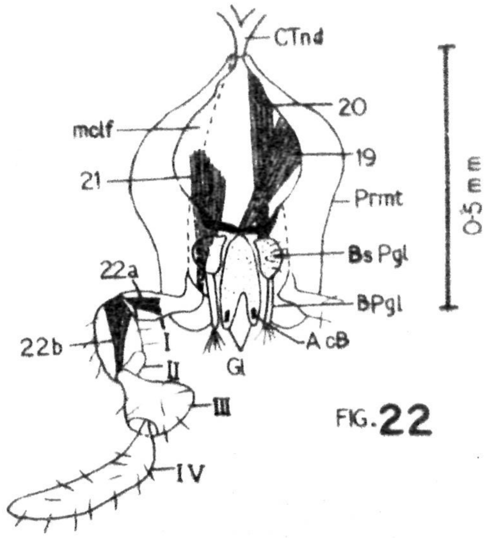

FIG. 22

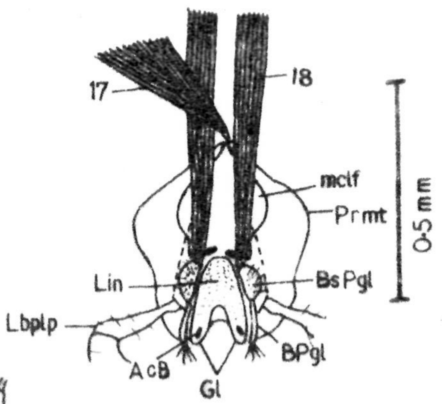

FIG. 23

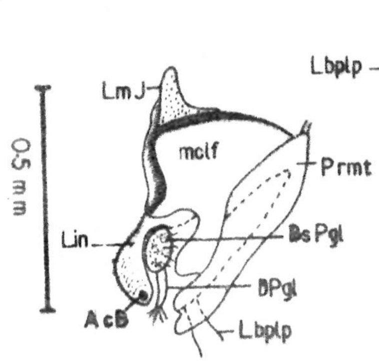

FIG. 21

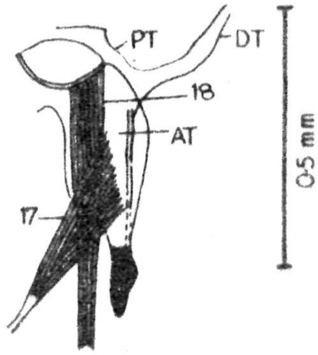

FIG. 24

PLATE VII

Fig. No. 25. Hypopharynx with its musculature

Fig. No. 26. Anterior view of labrum

Fig. No. 27. Anterior view of epipharynx

PLATE VII

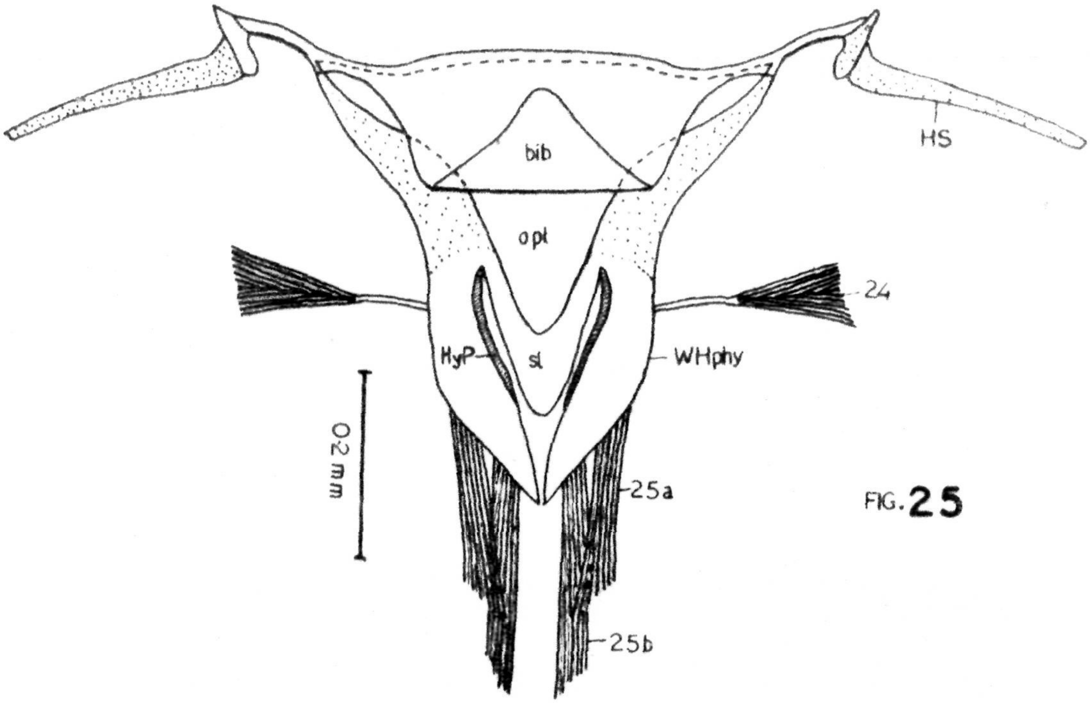

FIG. 25

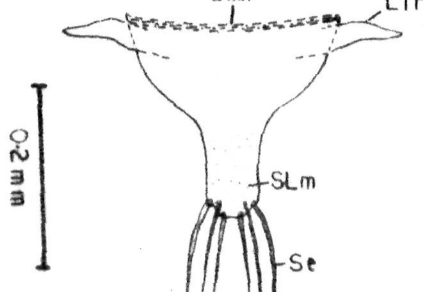

FIG. 26

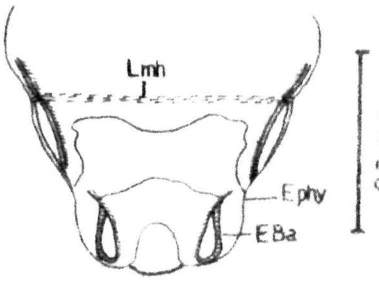

FIG. 27

PLATE VIII

Fig. No. 28. Labrum, Epipharynx, and pharynx with musculature (Anterior view)

Fig. No. 29. Labrum, Epipharynx and pharynx with musculature (Posterior view)

Fig. No. 30. Labrum, Epipharynx, pharynx and Hypopharynx with musculature (Lateral view)

Fig. No. 31. Ventral dilator of anterior pharynx showing its origin with the knob of tentorial bridge

PLATE VIII

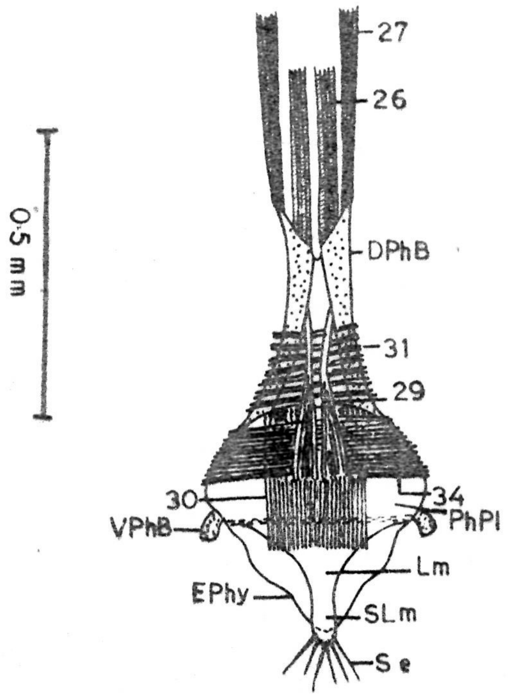

FIG. 28

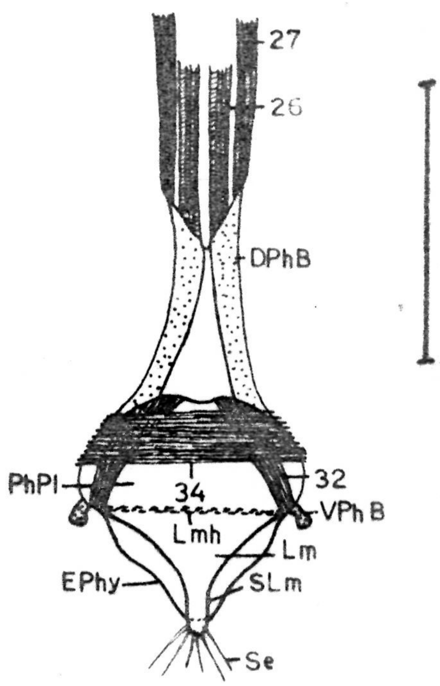

FIG. 29

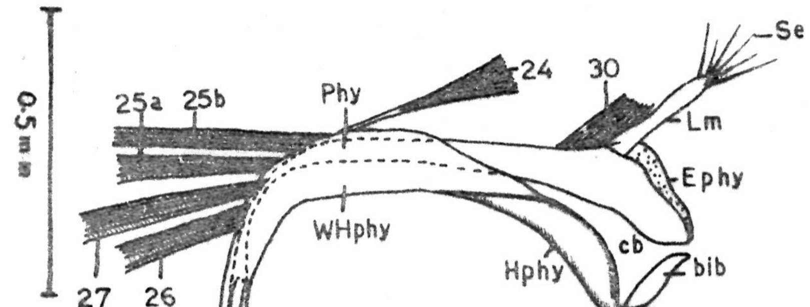

FIG. 30

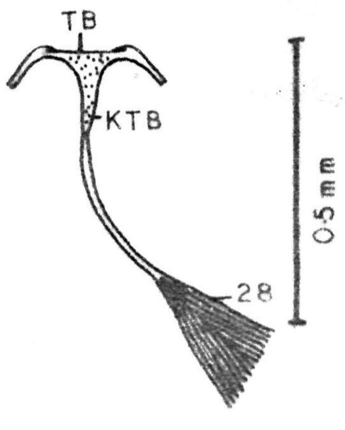

FIG. 31

PLATE IX

Fig. No. 32. Sagital section of the head capsule

PLATE IX

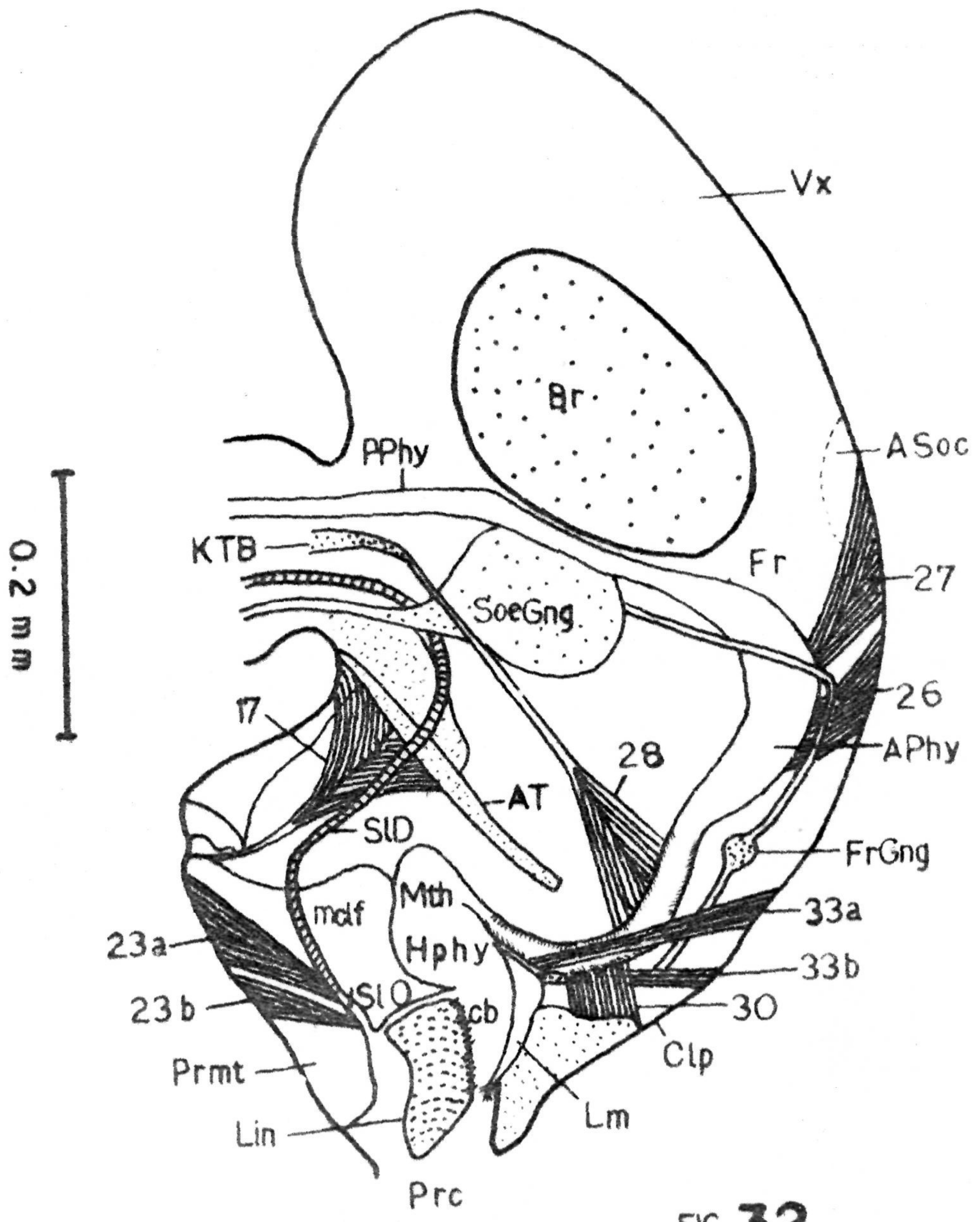

FIG. 32